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PART A: INTRODUCTION AND BACKGROUND INFORMATION

1. INTRODUCTION AND SCOPE OF MANAGEMENT PLAN

During the summer of 2007, the Goose Lake Coalition initiated our Irrigated Lands Regulatory Program (ILRP) Phase 1 monitoring effort. Corresponding to the beginning of the Goose Lake Basin irrigation season, our first sampling event took place on May 15, 2007, with subsequent samples collected monthly throughout the remainder of the season. Due to extreme drought conditions, the irrigation season ended in early July as did the Coalition's sampling efforts for the year.

As described in the Coalition's current Monitoring and Reporting Program Plan (MRPP), Lassen and Willow creeks are the focus of the sampling effort. During the 2007 season, *Ceriodaphnia dubia* (water flea) toxicity was detected multiple times at the same location in Lassen Creek, thus triggering the requirement for the Coalition to develop a management plan. As described in this plan, follow-up testing in the form of Toxicity Identification Evaluations (TIEs) were largely inconclusive, leaving the Coalition without many leads as to what could be causing the water flea toxicity. Thus, this management plan describes what is known about the Lassen Creek watershed and outlines the design for a source study that will be initiated during the spring of 2008 to help determine the source of the toxicity.

This plan has been prepared by the Goose Lake Resource Conservation District (GLRCD), which essentially administers the Goose Lake Coalition. The GLRCD has ensured that the Coalition remains in compliance with the ILRP while also working to incorporate the monitoring and reporting requirements for irrigated agriculture into the basin's existing watershed program that has been improving water quality and watershed health for more than fifteen years.

Responsible parties and roles. As the lead agency for the Goose Lake Coalition, the GLRCD will coordinate implementation of the Lassen Creek Management Plan. Herb Jasper, a member of the GLRCD, serves as the primary leader for the Coalition. He oversees overall project progress and is a primary point of contact. Julie Laird is the GLRCD's project manager. Under Mr. Jasper's direction, she will ensure that the management plan is implemented as described in Part B of this plan by coordinating all necessary parties and working with the field lead to carry out monitoring on schedule. Ms. Laird is responsible for compiling results and preparing management plan reports. Don Lancaster is the field sampling lead and ensures that field sampling is carried out appropriately and samples are delivered on time to laboratories.

Advisory Group. The Goose Lake Advisory Group was formed to provide guidance during development and implementation of the Lassen Creek Management Plan. The Advisory Group consists of the following individuals:

- Dr. Kenneth Tate, UC Davis Extension Rangeland Watershed Specialist
- Sabra Purdy, UC Davis graduate student, Lassen Creek (and Regional) bioassessment studies
- Stephen Clark, Pacific Ecorisk, Toxicity Testing Oversight
- Dennis Heiman, CVRWQCB, Redding Office
- Margie Read, CVRWQCB, Sacramento Office
- Susan Fregien, CVRWQCB, Sacramento Office
- Don Lancaster, UC Cooperative Extension (UCCE) Farm Advisor, Modoc County
- Herb Jasper, GLRCD, Project Director
- Julie Laird, GLRCD, Project Manager

2. Watershed Description and Land Use Information

In order to help determine the source of the *C. dubia* toxicity observed in Lassen Creek, it is important to understand the relevant watershed conditions, including the geologic and hydrologic setting, land use and land ownership patterns, the unique water chemistry of the basin, patterns of climate variability and characteristics of Lassen Creek's tributaries. This information is presented below in order to aid in the interpretation of monitoring results and to help identify any factors that could be contributing to the results of the *C. dubia* toxicity test.

Geologic and hydrologic setting: Lassen Creek lies within the Goose Lake Basin watershed, which stretches across the border between northeastern California and south-central Oregon. As a whole, the high desert Goose Lake watershed encompasses 1,140 square miles of land that drains from both the west and the east into Goose Lake, a closed-basin lake system that no longer has a surface outlet to the nearby Pit River. The last recorded lake overflow occurred in 1868, when after a series of extremely wet years, the lake did contribute some surface flow into the Pit River system. Currently, a low, gravelly terrace separates the lake from a marshy meadow. Most of the significant perennial tributary creeks within the California portion of the basin (including Lassen Creek) flow westward out of the Warner Mountains toward Goose Lake which itself covers thirteen percent of the entire area of the basin. Elevations within the watershed range from 8,000 feet in the Warner Mountains down to 4,693 feet at average lake level.

The annual precipitation throughout the Goose Lake Basin typically ranges between 15 and 20 inches, much of it occurring as snow. Vegetation is diverse and ranges from mixed conifer forests in the mountains to sagebrush-dominated shrublands, grasslands, and marshes descending from the mountains towards the lake.

The California portion of the Goose Lake Basin is sparsely populated with the majority of residents living in or near the communities of New Pine Creek, Willow Ranch, and Davis Creek. In 2000, the total population of Modoc County was estimated at 9,449. The communities within the Goose Lake Basin contribute a few hundred residents to that total at best. U.S. Highway 395 runs through the entire length of the watershed, and numerous county and Forest Service gravel roads also contribute to the transportation infrastructure of the area. A small railroad line also traverses the more gentle slopes of the Basin close to Goose Lake.

The Lassen Creek watershed itself has a northwest aspect and is approximately 14 miles long. The upper reaches of the watershed lies within the Modoc National Forest at elevations reaching nearly 7,500 feet. Moving down from the mountains, Lassen Creek stair steps its way to Goose Lake through a series of small mountain meadows and steep canyons. As one of only two perennial streams that reach Goose Lake on the California side of the basin, Lassen Creek provides critical cold-water habitat for trout, as well as other native fish and invertebrates. Four of these native fish species occur only in the Goose Lake Basin. They include: Goose Lake redband trout (*Oncorynchus mykiss*), Goose Lake sucker (*Catostomus occidentalis lacusauserinus*), Goose Lake tui chub (*Gila bicolor thalassina*), and Goose Lake lamprey (*Lampetra tridentata*). Though these species spend much of their adult lives in Goose Lake, they rely heavily on Lassen Creek for their spawning and rearing habitat. During periods of prolonged drought (multiple consecutive years) when Goose Lake goes dry, the creek helps to also provide emergency refuge for these and other aquatic species.

Stream flow in Lassen Creeks is generated by snowmelt in the higher elevations of the watershed, with peak runoff occurring during snowmelt in the spring (April until mid-May). By the end of July, stream flow is significantly diminished and is primarily spring-fed other than occasional rainstorm events during this base flow period. Stream flow is diverted into open irrigation delivery ditches usually starting in May and ending in June or July, depending on the annual snowpack conditions and stream-flow levels.

Land Use and Ownership Patterns: Within the California portion of the Goose Lake Basin, approximately 50 percent of the land is privately owned, with land use having changed little over the last 70 years. Private lands are used predominately for livestock grazing, but are also important for both irrigated and dryland hay production. There are approximately 9,000 irrigated agricultural acres within the California portion of the Goose Lake Basin. Major crops include alfalfa hay, orchardgrass hay, native meadow hay, and irrigated pasture. The remainder of the land is publicly owned and predominately managed by the U.S. Forest Service and the Bureau of Land Management (BLM). These public lands are managed for multiple-use with livestock grazing and dispersed recreation being two of the most predominant uses. Overall, less than four percent of the land area in the basin is cultivated, and fertilizers and pesticides are rarely applied. Based on a review of DPR's Pesticide Use Database (CalPIP 2008) and consultation with the Modoc County Agricultural Commissioner, no pesticides have been applied within the California portion of the Goose Lake Basin since 2003.

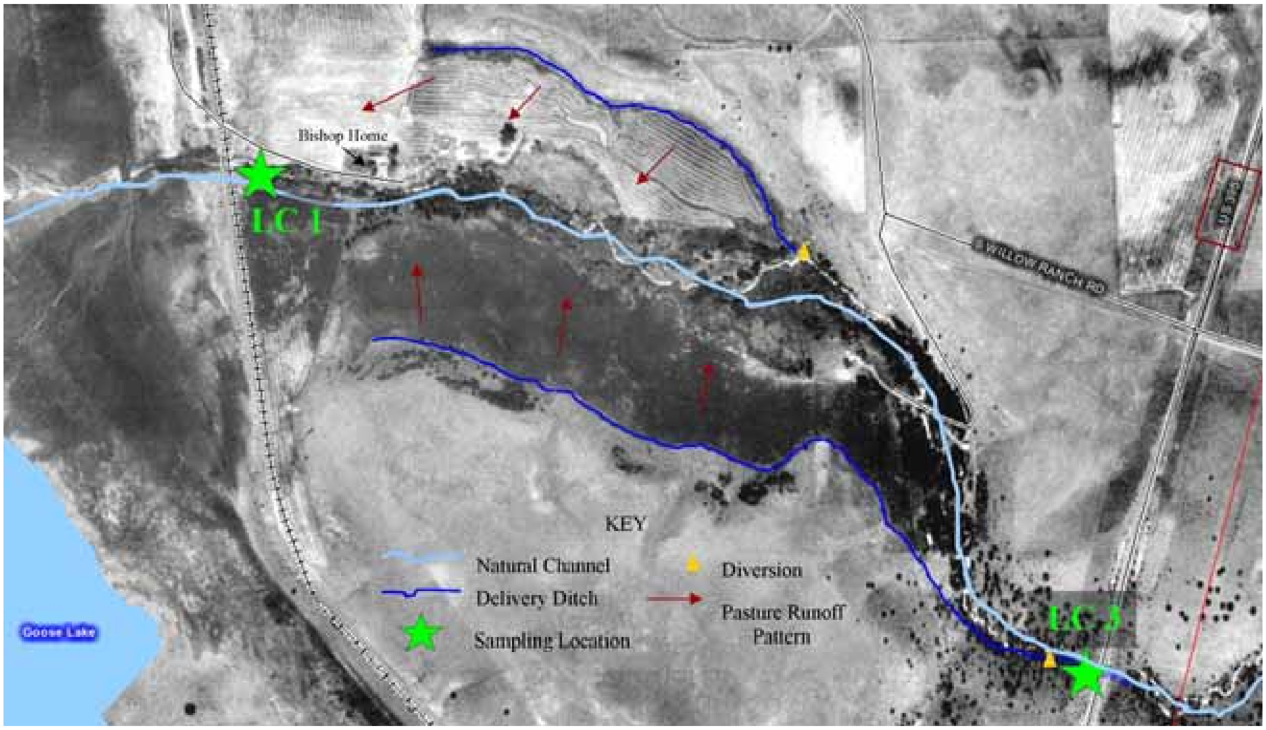
The Lassen Creek watershed is one of the primary places where irrigation is carried out through flood irrigation alone. Groundwater is not utilized for irrigation within the Lassen Creek watershed. This is also the case for the neighboring Willow Creek drainage. Irrigation return flows re-enter Lassen Creek and ultimately flow into Goose Lake.

The land use pattern in the Lassen Creek drainage follows the general description given for the Goose Lake Basin as a whole. Lassen Creek originates in predominately publically owned forestlands that are managed for dispersed recreation and livestock grazing and limited timber harvest. As the creek flows out of the Warner Mountains towards Goose Lake, land use focuses on dryland alfalfa and native meadow hay production, as well as irrigated pasture for livestock.

Currently, the land bordering Lassen Creek below Highway 395 is used for irrigated hay production and has been for many years. Similar to neighboring fields, the landowner that manages the land typically is able to harvest one cutting of hay off these fields and then grazes the re-growth with his cattle in late summer and early fall. Other than haying the fields, the only other common management practice on this portion of the Lassen Creek watershed is to drag the meadow fields in the spring to help distribute the manure deposited while cattle were present. The manure helps to act as a natural soil additive.

Irrigation System Information: A diagram of the Lassen Creek flood irrigation system along with the monitoring sites (LC 1 and LC 3) included in this management plan are shown in Figure 1. As shown in the diagram, all irrigated agriculture activities within the Lassen Creek watershed take place below where Highway 395 intersects the stream. There are two primary diversion points, with the first (farthest upstream) diversion delivering water to fields on the south side of the stream, while the second diversion provides water to the north side. Both delivery ditches are earthen in construction other than limited segments of polyvinyl chloride (PVC) pipe. Water is distributed out of the ditches by the use of tarp dams. Please also note that one residence is shown in the photo. The home belongs to the absentee owner of much of the lower Lassen Creek property and serves more as a vacation home than a permanent residence.

Figure 1. Diagram of the Lassen Creek flood irrigation system.



Further, in the aerial photo of Figure 1, the light blue line that denotes Lassen Creek's natural channel does not perfectly follow the actual location of the stream (which can be seen as the white line through most of the photo.) The natural channel line was drawn in by the mapping program used to generate the aerial photo and thus could not be changed in the creation of this diagram.

Lassen Creek Tributaries: Lassen Creek has one major perennial tributary, which is aptly named Cold Creek. Previous monitoring has revealed that the flow of this tributary stream averaged 6°F cooler than the main body of Lassen Creek. Cold Creek's confluence with Lassen Creek is in the upper forested portion of the watershed, well above where Highway 395 intersects the creek and before any irrigated agriculture takes place.

3. Summary of the 2007 Lassen Creek Monitoring Results

In accordance with the Coalition's MRPP, monthly sampling was conducted during the 2007 irrigation season from May until July. As mentioned in Section 1 of this plan, the Goose Lake Basin experienced drought conditions during the summer of 2007. Thus, by mid-July, there was no longer adequate volumes of stream water to obtain accurate and representative samples and the monitoring season was concluded with the 7/3/07 sampling event.

As described in the Coalition's MRPP, the LC 1 (Lower Lassen Creek) monitoring site was established in the Lassen Creek drainage below all irrigated agriculture activities within the watershed. Because *C. dubia* toxicity was detected at LC 1 in 2007, the Coalition added two upstream monitoring sites later in the season to help determine the source and/or cause of the problem. A complete report of the 2007 monitoring results for all sites and parameters is available in the Goose Lake Coalition's Semi-annual Monitoring Report (December 31, 2007). The results discussed in this management plan focus on the Lassen Creek *C. dubia* toxicity test results and potentially relevant parameters that were also measured.

Significant *C. dubia* toxicity was observed at the LC 1 monitoring site during three of the four sampling events conducted in Lassen Creek during 2007. A summary of the Lassen Creek toxicity results is presented in Table 1. Since significant toxicity >50% was observed in the toxicity tests conducted on the May 15 (event 1) and May 24 (event 2) samples, TIEs were performed per the MRP requirements. However, the toxicity was not persistent in the water samples and, therefore, the TIEs did not indicate what might have caused the toxicity. The analytical laboratory suggested that the condition causing the toxicity is either: 1) not stable in the water column so that it has already degraded beyond detection levels by the time a TIE is initiated, or 2) occurs at a level that is low enough to just begin having an effect on *C. dubia* survival allowing the potential chemical to quickly degrade to a level where it is no longer toxic to *C. dubia* and thus not have any affect on the insects during the TIEs.

Based on the lack of a known cause for the Lassen Creek *C. dubia* toxicity, the Coalition considered the possibility that natural, ambient water conditions might be causing the toxicity. The Coalition adopted a strategy to conduct additional monitoring and analyses that might confirm this theory or provide evidence to narrow down potential causes. During the third monitoring event on June 20, the LC 2 (Upper Lassen Creek) monitoring site was added to determine whether toxicity was present in the upper watershed. LC 2 is located in the Modoc National Forest near the creek's headwaters above where any irrigated agriculture impacts potentially take place. The site is also below Cold Creek's confluence with Lassen Creek Significant toxicity was observed in the sample collected from LC 1 (40% survival), which is below the irrigated agriculture, but was not observed in the sample collected from the upper watershed at LC 2. The TIE results for the toxic LC 1 sample were not considered usable because the TIE control tests did not meet quality assurance criteria.

During the fourth monitoring event on July 3, the Coalition added the LC 3 (Mid Lassen Creek) site to determine whether toxicity was occurring lower in the watershed, but still above the influence of irrigated agriculture. In consultation with the CVRWQCB and Pacific EcoRisk, the Coalition developed a new strategy for this sampling event. Since samples from the LC 1 site had consistently caused reductions in *C. dubia* survival throughout the monitoring season, the Coalition asked the laboratory to immediately initiate a Phase 1 TIE on the LC 1 sample collected on 7/3/07 instead of first conducting the 96-hour regular toxicity test. Since previous results indicated that the toxicity was not persistent in the water samples long enough to be detected by the TIEs, the Coalition felt that this strategy of initiating an immediate TIE would increase the chances of obtaining meaningful results from the test. However, no information was gained from these tests because toxicity was not present in any of the samples. A summary of the 2007 TIE results is presented in Table 1 on the following page.

Table 1. Results for *C. dubia* toxicity tests, TIEs, flow, total dissolved solids, and turbidity, 2007 irrigation season at Lassen Creek, Goose Lake Basin.

	EVENT 1 5/15/07	EVENT 2 5/24/07	EVENT 3 6/20/07	EVENT 4 7/3/07
LC 1				
Lower Lassen Ck				
Toxicity (% survival)	**15%**	**20%, 60%**	**40%**	100%
TIE result	Non-persistent	Non-persistent	Invalid result	No toxicity*
Flow (cfs)	7.7	No data	2.2	0.86
TDS (mg/L)	84	No data	105	No data
Turbidity (NTU)	8.6	No data	5.7	No data
LC 2				
Upper Lassen Ck	Not applicable	Not applicable		Not applicable
Toxicity (% survival)			85%	
TIE result			Not applicable	
Flow (cfs)			3.8	
TDS (mg/L)			66	
Turbidity (NTU)			3.3	
LC3				
Mid Lassen Ck	Not applicable	Not applicable	Not applicable	
Toxicity (% survival)				100%
TIE result				Not applicable
Flow (cfs)				1.9
TDS (mg/L)				No data
Turbidity (NTU)				No data

* Significant toxicity >50% was observed in the *C. dubia* toxicity tests performed on the May 15 and May 24 LC1 samples. However, the associated TIE's indicated non-persistent toxicity. In an attempt to identify the cause of toxicity, the July 3 TIE was conducted concurrently with the *C. dubia* toxicity test. However, toxicity did not occur in either test performed on the July 3 sample.

In addition to the above steps initiated by the Coalition, a portion of the May 24 water sample collected from LC1 was sent to an analytical laboratory to determine trace metals concentrations. The following section describes the purpose and results of this analysis.

Follow-up Metals Analysis: Because there are no records of chemical applications, and pesticides have not been used in the Basin since 2003, the Coalition does not have any strong leads as to what may be causing *C. dubia* toxicity in Lassen Creek. During the 2007 season, follow-up sampling was conducted in Lassen Creek in an effort to narrow down possible causes of the toxicity.

The Coalition decided to have a metals analysis performed on the persistency sample collected on 5/24/07. Previous monitoring data collected by CVRWQCB staff and UCCE indicated that some metals (particularly copper) can be moderately high in Goose Lake Basin waterbodies. Accordingly, in consultation with CVRWQCB staff and Pacific EcoRisk, the Coalition decided to analyze the 5/24/07 sample for specific metals to possibly eliminate metals as a cause for the toxicity observed in Lassen Creek. Because metals tend to be stable and not degrade, and the TIE results indicated that toxicity was not persistent in the original samples, this suggested that metals were not the cause of toxicity. However, the Coalition decided to have a metals analysis performed to verify that metals concentrations were too low to cause toxicity. . The results of these tests are shown in Table 2. Further, the hardness of the LC 1 5/24/07 sample was 28 mg/L.

Table 2. Follow-up Metals Analysis to help determine the cause of the *C. dubia* toxicity (hardness=28 mg/L).

Date	Site	Metal	AnalyticalMethod	Results	Units	Criterion	RL
5/24/07	LC 1	Arsenic	EPA 200.8	0.7	µg/L	10	0.5
5/24/07	LC 1	Boron	EPA 200.7	0.025*	µg/L	700	0.1
5/24/07	LC 1	Cadmium	EPA 200.8	ND	µg/L	0.91[ϒ]	0.1
5/24/07	LC 1	Copper	EPA 200.8	1.6	µg/L	3.1[ϒ]	0.5
5/24/07	LC 1	Lead	EPA 200.8	0.09*	µg/L	0.63[ϒ]	0.25
5/24/07	LC 1	Nickel	EPA 200.8	1.3	µg/L	18[ϒ]	0.5
5/24/07	LC 1	Selenium	EPA 200.8	ND	µg/L	5	2
5/24/07	LC 1	Zinc	EPA 200.8	5*	µg/L	41[ϒ]	10

* Results followed by an asterisk (*) denote values above the laboratory method detection limit but below the reporting limit. ϒ = Criteria are calculated using the California Toxics Rule hardness-based formulas for protection of freshwater aquatic life. The hardness of the LC 1 water sample collected on 5/24/07 was 28 mg/L.

As shown in Table 2, several metals were detected in the sample from LC 1. Pacific EcoRisk reported that they were all below the known thresholds for *C. dubia* toxicity. As expected, these analyses primarily served to cast doubt on the possibillity that metals are the primary cause of the *C. dubia* mortality in Lassen Creek. However, peer-reviewed studies show that *C. dubia* toxicity to metals is dependent on a variety of chemical factors, including alkalinity, pH, total organic carbon, and hardness. These factors affect the toxicity of each metal differently. Furthermore, there is evidence that combinations of metals can have synergistic effects on toxicity. Further explanation and references are provided in Part A, Section 4 of this plan.

4. Existing Literature on *Ceriodaphnia dubia*

Since *C. dubia* toxicity was detected in Lassen Creek during the 2007 monitoring season, the CVRWQCB, toxicity lab, and Coalition staff have searched for existing scientific literature that describes the water quality characteristics and common chemicals known to affect the organism's survival. Though a full analysis of the existing literature will be made at the end of the 2008 season in order to help explain and interpret the results of the monitoring, a brief summary of factors known to affect *C. dubia* survival is included here.

Two of the identified research papers in particular help explain the relationship between various water quality parameters and the toxicity of certain metals to *C. dubia*. Factors that are known to affect the toxicity of trace metals include alkalinity, pH, dissolved organic carbon, and hardness (Hyne et al. 2005; Cowgill and Milazzo 1991). As described in more detail in these papers, these factors affect the toxicity of specific metals on *C. dubia* differently. For example, while alkalinity and dissolved organic carbon affect the toxicity of copper to *C. dubia,* hardness does not. Conversely, hardness is the most important factor in the toxicity of zinc to *C. dubia*. Additionally, studies have shown that synergistic effects can occur when combinations of metals exist (Shaw et al. 2005; Dixon 2004; Spehar and Fiandt 1986). Therefore, some additional data regarding the concentrations of important parameters, together with the metals of interest will indicate whether metals are a possible source of toxicity.

Past research has also indicated that other naturally occurring water conditions can affect *C. dubia* survival. For instance, laboratory tests have shown that *C. dubia* is sensitive not only to low levels of calcium carbonate ($CaCO_3$), but also to changes in the alkalinity of the water (Lasier et al. 2006).

The preliminary examination of these studies has helped guide the selection of water quality parameters and analysis methods to be utilized in this management plan. We will utilize the papers cited above, as well as the other key studies listed in the References section of this document to better understand and analyze the results of the 2008 source study monitoring to help determine if discharge from irrigated agriculture is contributing to the *C. dubia* toxicity in Lassen Creek.

5. Previous Water Quality Research Efforts

The Goose Lake Basin has been the site of on-going monitoring efforts and watershed-wide cooperation since the early 1990's when concerns arose over the status of the basin's redband trout after a series of low water years left Goose Lake completely dry in 1992. These studies contain data and information that will be valuable in interpreting and understanding the results of the 2008 source study monitoring efforts. Though a complete analysis of how the past monitoring efforts can be used to better understand the source of the *C. dubia* toxicity will be conducted after the 2008 sampling season is complete, a brief summary of each past research effort is included below in order to describe the type of information that is available and how it might be relevant to the *C. dubia* toxicity source study.

Physical Water-Quality Parameter Monitoring: In 1993, a water quality monitoring program was initiated by Dennis Heiman of the Central Valley Regional Water Quality Control Board (CVRWQCB) to evaluate the existing condition of the major water bodies within the basin and thereby determine if any water quality parameters were at levels that would negatively impact aquatic life or other beneficial uses. This monitoring effort was conducted through 1998, with

Lassen Creek being one of the major waterbodies sampled. The results showed that measured water quality parameters (including pH, conductivity, dissolved oxygen, nutrients, metals, and standard minerals) were generally at levels that would not adversely impact aquatic life or the other identified beneficial uses of the waters. Results from the metals analysis indicated that copper, lead, cadmium, and zinc are regularly detected in Lassen Creek water samples. Though none of the metals concentrations were particularly high, 1997-1998 copper and lead concentrations did exceed the hardness-based toxicity criteria for the protection of freshwater aquatic life. As previously discussed, other water quality factors can affect the toxicity (or bioavailability) of the metals. Thus, the results of this previous research effort have helped guide the selection of parameters to be sampled as part of this source study. A copy of the complete summary report is included as Appendix A of this plan.

Past Irrigated Agriculture Discharge Monitoring: A more recent monitoring effort undertaken in the Goose Lake Basin began as a result of the changing requirements for agricultural discharges in 2003. Recognizing that the previous irrigated agriculture conditional discharge waiver granted by the CVRWQCB was being replaced by a new compliance process, the GLRCD and the UCCE service in Modoc County and at UC Davis realized the need to begin studying and trying to quantify the effects of irrigated agricultural discharges to the streams in the Goose Lake Basin.

As in previous research, these study efforts focused on Lassen and Willow creeks not only because of their importance in providing aquatic habitat for the basin's unique fish species, but also because they are the two streams on the California side of the basin that receive return flows from irrigated agriculture and also eventually reach Goose Lake. A research article summarizing the results of this study appeared in the July-September 2005 issue of *California Agriculture* Magazine and is included with this plan as Appendix B. Some of the most important conclusions are summarized below because of their usefulness in interpreting the results of the current monitoring program described in this plan.

The field work for this joint research project was conducted in 2003. Flow volume, electrical conductivity, turbidity, and dissolved oxygen were measured weekly during the irrigation season at each sampling location. In addition, approximately half of all the water samples were analyzed in a laboratory for total suspended solids, nitrate, ammonium, phosphate, sulfate, potassium, and dissolved organic carbon.

The monitoring strategy allowed for: 1) the examination of in-stream water-quality changes due to irrigation, 2) the examination of changes in water quality as irrigation water passes through delivery ditches and moves across pastures, 3) an accounting for the differences in flow volume for each water source, and 4) an accounting for changes in water quality and flow over the 2-month irrigation season.

As a result of this intensive monitoring effort, it was determined that in-stream electrical conductivity was significantly higher below the irrigation systems in both Lassen and Willow creeks than above the diversions. Laboratory analysis indicated that this increase was due at least in part to increased concentrations of potassium and sulfate. However, the potassium and sulfate levels do not represent significant water-quality problems. Sample analysis also indicated that mineral nitrogen levels in these systems appeared to be low, with nitrate and ammonium levels being only slightly above the detection limits of 0.001 parts per million (ppm) and well below those of water-quality concern (such as the drinking water standard of 10 ppm and mineral nitrogen stream eutrophication levels of concern of 0.1 ppm). Sample analysis also revealed that levels of turbidity and total suspended solids were not significantly higher below than above the irrigation systems on both streams.

6. References

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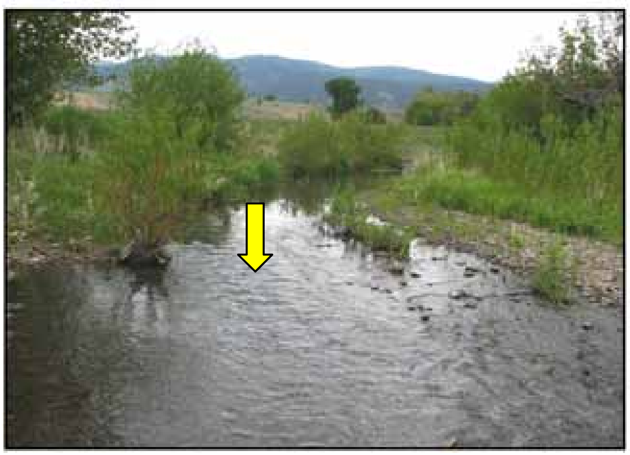
PART B: STUDY DESIGN FOR THE *CERIODAPHNIA DUBIA* SOURCE STUDY ON LASSEN CREEK

1. SAMPLE SITE DESCRIPTIONS

Two primary monitoring sites will be utilized in the study design for the *C. dubia* source study on Lassen Creek. Both locations were monitored in the Goose Lake Coalition's MRPP in 2007 and are thus known as "Lower Lassen Creek (LC 1)" and "Mid Lassen Creek (LC 3)" as described in Part A of this plan. Both of the sites are show on the map in Figure 4.

The LC 1 monitoring site is located downstream of all irrigated agriculture activities in the Lassen Creek drainage and is one of the original sites included in the Coalition's MRPP. The site is below Highway 395 but immediately above where the railroad crosses the creek. Directly upstream of the sampling site are irrigated meadows used for both hay production and livestock grazing. The sampling site is about 12 feet above a traditional crossing site where ranch vehicles and hay equipment move across the stream channel. All water and sediment samples are collected upstream of the crossing to avoid any influence of the crossing in our results. Figure 2 shows upstream and downstream views from LC 1. In the upstream photo, the creek appears fairly wide near the bottom of the frame because of the stream crossing. The yellow arrow in the photo shows the specific sampling location. In the downstream photo, the base of the railroad trestle is visible.

Figure 2. Lower Lassen Creek sampling site (LC 1), facing upstream (left) and downstream (right).

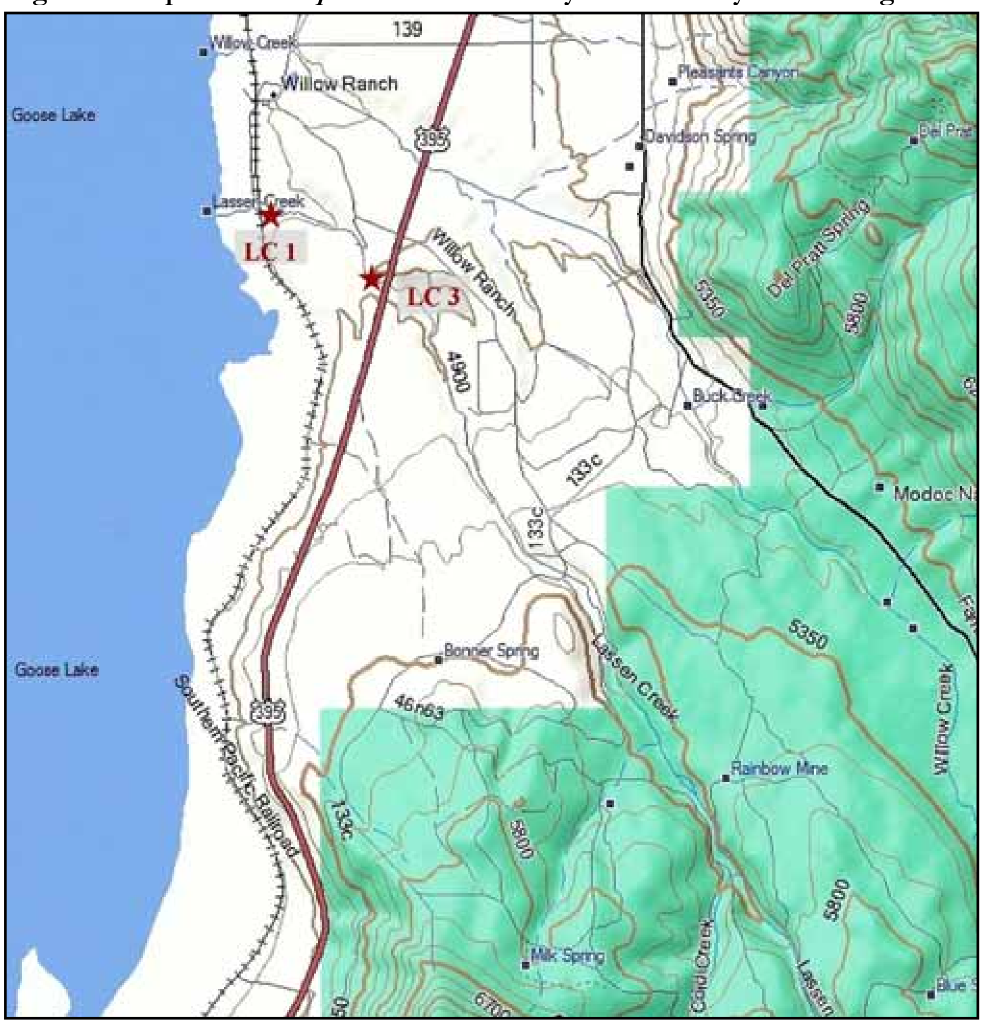


The LC 3 site is located near the middle of the Lassen Creek watershed. It is below the portion of the drainage that lies within the Modoc National Forest, but is immediately above any irrigated agriculture activity. Samples are collected directly below Highway 395 about 10 feet upstream of where the first irrigation diversion begins. This sampling site was added to the monitoring program during our July 3, 2007 sampling event to help determine the source and extent of the *C. dubia* toxicity observed at LC 1. Figure 3 shows upstream and downstream views from LC 3. In the upstream photo, the culvert under Highway 395 is visible. Please note that some foam appears in the picture as a result of the stream backing up at the first irrigation diversions (the photo was taken standing on top of the first diversion). The 2007 water samples were collected, however, from the clear portion of the channel. In the downstream photo, materials related to the irrigation diversions are visible in the stream.

Figure 3. Mid Lassen Creek sampling site (LC 3), facing upstream (left) and downstream (right).

Since LC 3 is located immediately above any irrigated agriculture activities and LC 1 lies below all irrigation, these two sites essentially bracket the portion of the Lassen Creek watershed that is affected by irrigated agriculture and provide an "above and below" perspective for this study design, as shown in Figure 4 on the right. (Note: The Rainbow Mine located along Lassen Creek is an obsidian mine, and thus not a likely source of metals or chemicals.)

Figure 4. Map of *Ceriodaphnia dubia* Toxicity Source Study Monitoring Sites.



Depending on the results of the 2008 monitoring effort, we may add additional monitoring sites between LC 3 and LC 1 as needed. In addition to other sites within Lassen Creek itself, other possibilities include sites such as: 1) the bottom of the irrigation ditch but above the field, and 2) at the bottom of the field but above the creek. Since our primary objective during the 2008 monitoring season is to ascertain if toxicity is occurring only during the irrigation season and only in the reach where irrigation takes place, the "above and below" approach of monitoring at LC 3 and LC 1 will provide the necessary information to satisfy that objective. If we do find that toxicity is related to irrigation operations, we will then strategize on what steps to take next in order to pinpoint where the problems are occuring.

The LC 3 and LC 1 monitoring sites were also selected because of their ability to help us answer the following questions:

- Is there equal or higher toxicity at LC3 (above the irrigation diversions) than at LC 1? If so, the data would suggest that agriculture is not the cause of the *C. dubia* mortality.
- If there is *C. dubia* toxicity below the irrigation diversions at LC 1, does it occur during the time period when diversion/irrigation is not happening and there is no runoff from the field? If so, the data again would suggest that agriculture is not the cause.
- If the *C. dubia* toxicity occurs below the irrigation diversions at LC 1, is there less or no toxicity above the diversions at LC 3? If so, the data suggests that agriculture could be a source of the toxicity, though further study would be required to establish this with certainty, given that a residential property lies between LC 3 and LC 1.
- Is the *C. dubia* toxicity occurring at LC 3 during spring snowmelt? If so, the data would suggest that agriculture is not the source during that time period.

2. Monitoring Strategy and Constituents to be Sampled

Given the results from the 2007 irrigation monitoring season, the information gleaned from the laboratory analyses of the *C. dubia* toxicity samples, our preliminary review of *C. dubia* literature, and the results of previous water quality monitoring efforts, we have designed this source study to capture the differences in several parameters that will help determine when, why, and where the toxicity problem is occurring. As described in this section, the source study will help us determine the differences in and possible affects of:

- Streamflow: We will determine whether the toxicity issue appears to be related to the amount of flow in Lassen Creek to help answer questions such as if higher flows provide a "dilution" type of effect versus low flow periods, or if during low base flow periods if the toxicity could be related to springs that contribute a greater percentage of water to the creek during those times.
- Irrigation and Diversion: We will be able to assess any differences in the toxicity results that occur when water is being diverted for irrigation and when it is not. Further, depending on the quantity of water available for irrigation this year, we may also have the opportunity to observe how specific diversions affect the toxicity results if the landowner takes water out of different combinations of diversions throughout the season.
- Season: The proposed source study design may also help us determine if there is any seasonal effect present in the toxicity test results. Given that our last LC 1 sample on July 3, 2007 was not toxic to the water flea, there has been some discussion of whether there could be some kind of seasonal pattern occurring that we only detected part of last year.

- Location: By testing directly above and immediately below irrigated agriculture activities on Lassen Creek, this study design provides for a comprehensive sampling scheme that will greatly help us in determining whether irrigate agriculture is or is not a potential source (or one of several sources) contributing to the *C. dubia* toxicity.
- Variation in Natural Water Characteristics: By sampling during the early spring snowmelt season as well as throughout the late spring and summer irrigation season, this study design may allow us to capture variations that occur in the natural water characteristics of Lassen Creek that are associated with flow conditions and the season. Based on the previous monitoring results and the water quality parameters to be measured in this study (as described below), we may be able to identify variations that occur in water chemistry that could also be affecting *C. dubia* survival.

The source study will be initiated during the early spring snowmelt/runoff season that typically occurs in the Goose Lake Basin from late March into early April. Unlike 2007, when the mountain snowpack was severely limited due to drought, the Basin has experienced adequate snowfall this winter to anticipate a more normal runoff and a sustained irrigation season for 2008. The snowmelt monitoring event for this source study will document water quality conditions and the presence or absence of the *C. dubia* toxicity *before* the irrigation season begins. As described above in Section 1, if the toxicity is present above the agricultural fields and before diversion of irrigation water begins, the results would suggest that agriculture is not a source of the toxicity during that time frame.

After the initial "pre-irrigation" sampling has been conducted during the snowmelt period, we will convene the advisory group to determine the sampling frequency for *C. dubia* toxicity at both LC 3 and LC 1. At the same time the toxicity monitoring is being conducted, we will sample for a select set (see Table 3 and Figure 5) of chemical and metals. Because these tests will provide a greater level of detail than Phase 1 Toxicity Identification Evaluation (TIE) tests, the chemical tests will be performed in lieu of conducting any TIEs (designed to determine the general class of toxicant only) if *C. dubia* toxicity is detected. Though previous Pesticide Use Reports (PURs) from the Modoc Agricultural Commissioner have indicated that no pesticide use has been reported since 2003, the chemical tests will either detect something that is not being reported and/or is residual from previously unknown land management activities, or they will confirm that the various chemicals of concern are not present in the watershed. Again, the advisory group will determine the frequency of the chemical and metals sampling after the results from the initial snowmelt event are available. For additional details regarding the rationale behind the chemical and metal analyses, please refer to Appendix C, the CVRWQCB's Plan for Chemistry Analyses of 2008 Goose Lake Samples.

In addition to the toxicity and chemical tests, we will conduct bi-monthly sampling of some of the general water quality constituents, including stream flow, temperature, dissolved oxygen, electrical conductivity, pH, total suspended solids, and turbidity. The more frequent sampling will not only help us determine any seasonal or flow-related changes in water chemistry, but will also allow us to detect if changes in any of these parameters might reach levels that are known to affect *C. dubia* survival. Other constituents will be sampled on a monthly basis, including total dissolved solids, total organic carbon, and *E. coli*. Lastly, for alkalinity, hardness, and dissolved organic carbon, sampling frequency will be determined based upon the decision of the advisory group once the results of the snowmelt event are available.

Lastly, through the Coalition's partnership with UC Davis, macroinvertebrate sampling will again be conducted this season. In 2007, Sabra Purdy, UC Davis graduate student, collected macroinvertebrate samples in Lassen Creek as part of a larger macroinvertebrate study the university is conducting. One of the specific stream reaches sampled included the area around the LC 1 monitoring site. Analysis of the sample revealed more than 50% of the sample as EPT species, or Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). These species are accepted as being the most sensitive to pollution, sedimentation, and temperature. In particular, the LC 1 macroinvertebrate sample showed good stonefly diversity, which are one of the most sensitive group of invertebrates, needing excellent water quality to survive. Overall, 16 out of the 34 genera within the 2007 sample had tolerance values of 3 or less (on a scale of 0 to 10, with 0 being the most intolerant of pollution and 10 being highly tolerant). The macroinvertebrate data to be collected in 2008 will be utilized to compare with these 2007 results as well as any previous data that is suitable for such comparison. Habitat information that can be tied to the macroinvertebrate community data will also be collected to add to our analysis.

Please note that the monitoring schedule, parameters to be monitored, and the mechanisms for collecting/analyzing the information (whether by field measurements or by laboratory analysis) is summarized below in Table 3.

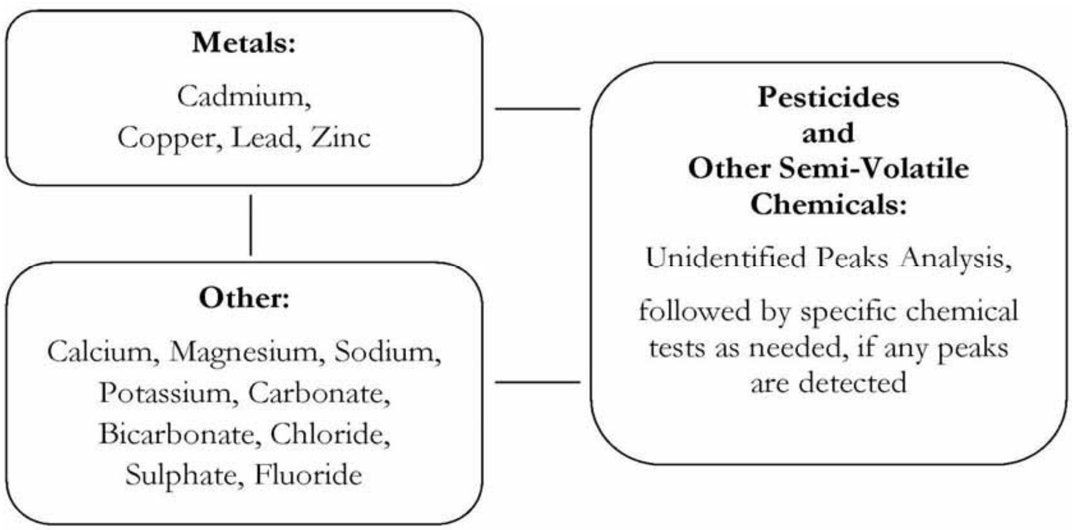
Table 3. Lassen Creek Management Plan monitoring schedule, parameters, and analysis methods.

CONSTITUENT	SAMPLING FREQUENCY	LOCATIONS	MEASUREMENT/ANALYSIS
Ceriodaphnia dubia toxicity	1 snowmelt event Frequency during irrigation season TBD based on Advisory Group Decision	LC 3 & LC 1	Pacific Eco Risk Laboratory
Specific chemical and metal tests (*See Figure 5 for constituents)*	1 snowmelt event Frequency during irrigation season TBD based on Advisory Group Decision	LC 3 &LC 1	Laboratory for analysis TBD by CVRWQCB
Instantaneous Streamflow	1 snowmelt event 2 events/month during irrigation season	LC 3 & LC 1	Field measurement
Temperature	1 snowmelt event 2 events/month during irrigation season	LC 3 & LC 1	Field measurement
Dissolved oxygen	1 snowmelt event 2 events/month during irrigation season	LC 3 & LC 1	Field measurement

CONSTITUENT	SAMPLING FREQUENCY	LOCATIONS	MEASUREMENT/ANALYSIS
Electrical Conductivity	1 snowmelt event 2 events/month during irrigation season	LC 3 & LC 1	Field measurement
pH	1 snowmelt event 2 events/month during irrigation season	LC 3 & LC 1	Field measurement
Total Suspended Solids (TSS)	1 snowmelt event 2 events/month during irrigation season	LC 3 &LC 1	Basic Laboratory, Redding, CA
Turbidity	1 snowmelt event 2 events/month during irrigation season	LC 3 & LC 1	Field Measurement *OR* Basic Laboratory, Redding, CA
Alkalinity	1 snowmelt event Frequency during irrigation season TBD based on Advisory Group Decision	LC 3 & LC 1	Laboratory for analysis TBD by CVRWQCB
Hardness	1 snowmelt event Frequency during irrigation season TBD based on Advisory Group Decision	LC 3 & LC 1	Laboratory for analysis TBD by CVRWQCB
Dissolved Organic Carbon	1 snowmelt event Frequency during irrigation season TBD based on Advisory Group Decision	LC 3 & LC 1	Laboratory for analysis TBD by CVRWQCB
Total Dissolved Solids	1 snowmelt event 1 event/month during irrigation season	LC 3 & LC 1	Basic Laboratory, Redding, CA
Total Organic Carbon	1 snowmelt event 1 event/month during irrigation season	LC 3 & LC 1	Basic Laboratory, Redding, CA
E. coli	1 snowmelt event 1 event/month during irrigation season	LC 3 & LC 1	Basic Laboratory, Redding, CA

Figure 5 lists the specific chemical and metal tests referenced in Table 3 that will be sampled for once during the snowmelt season and then at a frequency during the irrigation season that will be determined by the Advisory Group based on the results of the snowmelt event.

Figure 5. Specific chemical and metal tests referenced in Table 3.



3. Management Plan Implementation Schedule

The development and implementation of the Lassen Creek Management Plan was initiated in the fall of 2007, after the conclusion of irrigation season monitoring and the need for a management plan was identified. Beginning with an Advisory Group conference call on 19 October 2007 that included CVRWQCB staff, the Goose Lake Coalition leaders and staff, and the Coalition's support team from UCCE, we have since been working to assemble the various components of the plan and define the components of the source study.

In anticipation of the beginning of the 2008 monitoring season during the snowmelt/runoff period in late March/early April, we will continue to assemble as much information as possible on the Lassen Creek watershed and its land use, as well as about *C. dubia* and the water quality characteristics and common chemicals known to affect their survival. We will also continue assembling the data from previous research projects that will help document water quality conditions in Lassen Creek as well as provide insight into any trends or changes that may be taking place.

The initial monitoring phase for this management plan will begin with the snowmelt/runoff sampling event in late April or early May, depending on the timing of the peak spring snowmelt, and described in the previous section. The snowmelt monitoring will serve as our "before" irrigation measurements, which will hopefully be helpful in determining the source of the *C. dubia* toxicity. Once the results from the snowmelt event are available, the advisory group will convene to discuss the findings and determine the next specific monitoring steps and schedule (approximately two weeks following the monitoring event). If further management plan sampling is deemed necessary after the snowmelt event, monitoring will then continue into the 2008 irrigation season. It is anticipated that monitoring will occur approximately every 6-7 weeks during the irrigation season. The advisory group will determine how often samples should be taken for chemistry, *C. dubia* toxicity testing, and the other parameters as indicated in Table 3 following discussion of the snowmelt results. Throughout the 2008 season, the advisory group will be convened (via teleconference) to re-evaluate the management plan based on the results of each subsequent monitoring event. Prior to each conference call, monitoring results for the previous monitoring event will be compiled and distributed to the Advisory Group members.

Once the 2008 irrigation season has concluded and all data and lab analyses are available, we will again reconvene the advisory group to discuss the results of the original monitoring effort. At that time, we will discuss the conclusions that can be drawn from the season's monitoring and the outcomes (as described in Part A of this plan) of this initial source study. We will do a full analysis of the existing *C. dubia* literature as well as the previous water quality monitoring data available for Lassen Creek at this time, within the context of helping us interpret and understand the results of the 2008 monitoring season. All results and analysis will be provided in a management plan report to be submitted by 15 November 2008. Based on the monitoring results and the discussion of the advisory group, we will determine if additional information is needed or a continued source study is warranted.

4. Future Action Plan and Next Steps

As mentioned above, the results from the 2008 monitoring season will help us determine the next steps involved in this plan. We are hopeful that the initial results will give us enough information to determine whether or not irrigated agriculture is the source (or one of the sources) causing the *C. dubia* toxicity in Lassen Creek. If irrigated agriculture is determined to be a source or if we conclude that more information is needed before that determination can be made, the Advisory Group will be instrumental in determining the next steps for the Coalition.

In the case that agriculture is determined to be a source of the *C. dubia* toxicity, the advisory group will help determine the management practices, implementation schedules, and waste-specific monitoring plans that will be used to address the problem in future irrigation seasons.

We recognize that while the initial version of this management plan must be approved by the CVRWQCB for the 2008 monitoring season, the document will be refined and further developed depending on the monitoring results and the conclusions drawn by the advisory group. Thus, future versions of this plan will be drafted as needed.

APPENDIX A

Central Valley Regional Water Quality Control Board's

Water Quality Monitoring Report:

Lassen Creek, Willow Creek and Goose Lake

1993-1996 and 1997-1998 Addendum

APPENDIX B

UC Davis Irrigated Agriculture Discharge Study:

"Monitoring helps reduce water-quality impacts in flood-irrigated pasture"

APPENDIX C

CVRWQCB Plan for Chemistry Analyses of 2008 Goose Lake Samples